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is also more than probable that Messrs. Peter Lawson and Sons, No. 1, George the Fourth's Bridge, Edinburgh, the seedsmen to the Highland Society, may be able to supply the article required. For Cooper's early broad-leaved rye, I recommend an application to Mr. Thos. Cooper, of Ardleigh Wick, near Colchester, he being the only person whom I certainly know capable of supplying that valuable variety, the origin and history whereof I hope that he or some other able agriculturist will communicate to the public.

Should any farmer raise a supply of seed of the St. John's-day rye, for his own use, I strongly advise him to sow a part, but not the whole, so soon after the harvest as he can get it threshed, and to reserve one half of it to be sown in the following summer; for, however fine the season, and however warm and forward his land and situation, he will scarcely get it threshed out till near the end of July, which is a month later than the best season for sowing it, if he would see the plant in perfection. If he will sow the reserved portion at the Midsummer following, and is not thereafter satisfied with his produce, let him then impute to the author that he has been grossly misled.

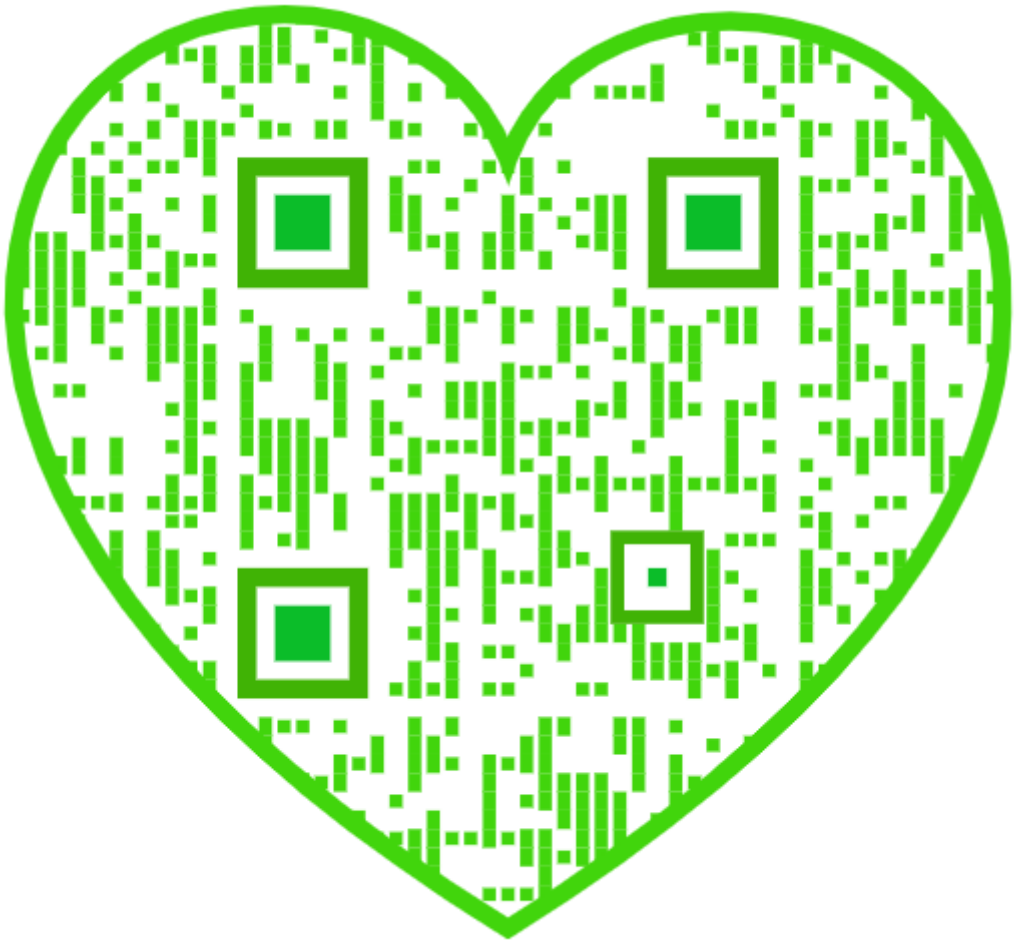
XXV.—*On the Potato Disease.* By F. J. Graham, B.A., F.L.S.

Prize Essay.

Of the innumerable hostile agents with which the cultivator of the soil has to contend, some he is able to keep in check by the ordinary course of husbandry; others have from time to time engaged the attention of men eminent in various departments of science. Still there is mischief in the field, the origin of which is not yet "dreamt of in our philosophy." Such *was*, perhaps still *is*, the subject of the present Essay—the Potato Disease of 1845, notwithstanding the most minute investigations have been made by some of the ablest Professors both in this and foreign countries in order to ascertain its real character. But probably few subjects of the kind ever presented greater difficulties, its cause being imperceptible, its attack inevitable, its remedy apparently impossible.

The first intimation I received of it was a mere rumour about the 12th of August, 1845; and on the 16th this was confirmed by Dr. Bell Salter in the "Gardener's Chronicle." I had then used my ashleaf kidneys and one bed of Fox's seedlings, without finding any sign of disease; but ten days afterwards, on taking up another bed of Fox's on the south side of a path which divided them, 2 bushels on two rods were more or less affected.

When the first bed was dug the haulm had not faded, but that



of the latter had in the mean time turned yellow, with brown spots on both leaves and stalks, and afterwards died off black. The roots were also decayed. In the garden of a nobleman in Warwickshire I also saw a crop grown within the walls, in which I could not perceive one unsound tuber, while those of a later sort grown in the border outside the walls were badly diseased.

On the 20th of August I had several roots of Shaw's taken up, which I found affected. The leaves were yellow, and the brown spots upon them spread rapidly, running down the petioles and forming circular blotches on the stalks, both above and below the point where the petiole was inserted, passing through the inner coats of the bark and the woody portion into the medulla, the structure of which was prematurely broken up at the lower extremity and stained of a dark colour, but remained for the most part healthy and entire towards the tops; blotches appeared also at the base, and on other parts of the stalks, and wherever these appeared the bark easily peeled off; and there were generally two or three distinct blotches on a stalk, with healthy-looking bark intervening, sometimes all these united. This crop was taken up on the 29th and 30th of August, at which time I found the tubers worse than when I tried them the week before; some of the roots were entirely diseased, others withered and dry, a few apparently sound. Many of the potatoes were marked with the too well known brown blotches; some in narrow uneven bands, separated by a small portion of sound substance; others were brown all over. The greater number were affected at that point where they were attached to the stalks or cords; these cords were nearly all diseased, yet a great many of the potatoes attached to them were quite sound. I also observed in some few cases that diseased potatoes were hanging to cords free from any trace of disease. Very frequently the cords broke off about three inches from the potatoes, where the disease had been most intense, and remained hanging to them.

The only way in which I can account for the entire crop not being destroyed is, that at the point of connection of the potato with the stalks or cords there is a sort of hylum as between the stalk of an apple and the spur on which it grows; and if the potato remains until ripe it separates spontaneously at this point, in the same manner as fruit. When, however, a fruit-tree is much checked in its growth by unusual drought, it is not uncommon for the footstalks to shrivel up, and for the fruit to remain hanging in its half-grown state to the spur. I believe the potato received just such a check during the hot weather of last autumn, and the cords shrivelled up in consequence, and became incapable of transmitting the mortiferous fluid to the tubers themselves: thus they escaped; and at the time of digging, as before observed, a very

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great number of these shrivelled cords still adhered to the potatoes.

The discoloration had not descended more than 1-8th of an inch under the cuticle, but a much greater quantity of the large potatoes was affected than of the small ones.

Two pieces of Jersey blue at this time, September 3, began to assume the same morbid appearance as the others; the tops, it is true, were green, but it was not of a healthy hue, and on a close inspection the awful spot was perceptible both on the leaves and stalks: most of the lower leaves and petioles were diseased; many had even fallen from their axils. I marked several plants, and picked off every spotted leaf, but in two days there were as many more, although the tops still continued of a sickly green colour, even after the blotches had encircled the stems.

The weather about this time was very hot and dry. These potatoes were taken up on the 22nd of September, nearly a month sooner than usual, and of these also the large ones were much more diseased than the small ones. A neighbour also, whom I supplied with sets of this variety, lost all except some of the small ones. The potatoes, however, did not generally grow so large last year as in ordinary seasons. I also observed at the time of taking up that a great number of the more slender plants which were quite dead, and appeared therefore to have yielded to the first attack (as the tubers all parted from the roots), had not a single unsound potato under them, while the strongest plants, of which the haulm at top continued green to the last, had in many cases not a sound one attached to them. My loss was heaviest on the blue, and, including those picked out since they were taken up, amounted to one-sixth of the crop.

The above is a brief description of the appearance both of early and late sorts; the former being constitutionally the most tender, the latter the most robust.

I have examined many other crops in several counties of England, but found them differ only in degree: of some upwards of 9-10ths being destroyed, of others scarcely any.

It has been generally considered that the disease was quite new to this country. I am, however, inclined to think otherwise, if only from the following circumstances which have come under my own observation:—

In 1841 I purchased one ton of York red potatoes in London, for planting, and while they were being cut I noticed exactly the same kind of blotches upon them running about ¼ of an inch under the skin, and containing the same dark shiny kind of fluid; and although these parts were cut out, more than half of the sets never came up, and the shoots of those that did were not thicker than straws, and many of these rotted off in blotches afterwards. (Just

the same result has taken place this year with *some* diseased sets which I planted for trial, although *some others* produced tolerable plants.) In the autumn of the same year, while taking up some Shaws, I also had several bushels discoloured in a similar manner to those of last year; some partially, others all over. It did not, however, occur to me to examine the haulm at that time; but I have referred to the persons who took up the crop, and find they also remember the circumstances above related. I have also been informed that this disease has been known for some years on the warp lands in Yorkshire in cold wet seasons. It has also been stated in the "Gardener's Chronicle" to have been prevalent in a part of Ireland for the last three or four years, and in one place in the Isle of Thanet in 1844; and I have little doubt, from the tons of diseased potatoes which I have seen thrown away by one grower in such seasons, that it has often visited us before; but never having been so universal, nor the press so available to make known the disasters to which the agriculturist is liable, it has passed among other injuries which, from their frequency, he is accustomed to slight.

It has also been supposed that certain sorts were less obnoxious to the disease than others, especially those recently raised from seed, from a notion that the old sorts were superannuated, for which there is not the least foundation; for very few really old sorts are retained in general cultivation, having been superseded by the Jersey Blue, Prince Regent's, and many other comparatively recent sorts, which were as much affected as any of the older kinds in some places, if less so in others. And as to last year's seedlings, I can state, from my own experience of a few I grew, that *they* were equally affected.

The only sorts which escaped entirely if allowed to ripen were the ashleaf kidney and early frame, where planted forward. And by a letter received from the Rev. J. Robertson, Secretary to an Agricultural Society at Bridgtown, Nova Scotia, whose duty it was to lay the returns of that province before the House of Assembly, I learn that the only sort which escaped there was a *very early* kind called "blue noses," and this was not touched, while of their later kinds 7-8ths were destroyed. I have no means of satisfying myself as to the collective loss in this country, but probably it would amount to about one-half of the crop. These were, however, by no means wasted; some having been converted into starch, which unless proper apparatus was employed was a troublesome process, and the drying difficult. I did not obtain more than 8 lbs. of fine starch to the bushel, as there was some waste, and the potatoes could not be grated entirely by hand. But the greater part were given to cattle, which throve very well upon them if boiled, or even given raw in moderation.

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As regards the weather of the year 1845, this had been very favourable for planting and hoeing, and the appearance of the growing crops was for the most part as promising as could be wished up to the beginning of July, when they were rather at a stand for want of some showers, the weather having been very dry and hot, with only one or two slight exceptions, for six weeks, the thermometer ranging in fact, according to the registry kept at the Horticultural Society's Garden, from $1\frac{1}{2}°$ to $4\frac{1}{2}°$ *above the average* for the last *nineteen* years; in short, it was beautiful hay-making weather. It then suddenly changed to the most extraordinary contrast that ever I witnessed even in this fickle climate; the atmosphere being for upwards of three weeks one continued gloom, the sun being scarcely ever visible during that time, with a succession of the most chilling rains and some frost; and for six following weeks the thermometer ranged but from $1\frac{1}{2}°$ to $7°$ *below the average* for the last nineteen years. Still the crops, upon a *general view*, did not look worse than they usually do after being beaten about by heavy rains; that is to say, they had a soddened appearance. That they had become debilitated I cannot entertain a doubt, but they exhibited at that time no other signs of it than that. But again the weather became suddenly dry and hot, and continued so up to the latter part of September, at which time the light lands were as dry as dust as deep as the plough had penetrated. I of course only speak of those places which I visited; but I may perhaps be allowed to state, upon the authority of the gentleman before mentioned, who is also the occupier of one or two farms, that a similar extreme variation of the weather occurred in Nova Scotia, namely, "very *unusual cold rains, suddenly succeeded by* 90° *of heat.*" It also appears from accounts from France, Belgium, and other countries visited by the disease, that their season was very similar. M. J. Decaisne, in his excellent "History of the Potato Disease," p. 75, says, "The *unusual heat* at the beginning of July was suddenly succeeded by a long continuation of *extraordinarily cold, humid,* and *cloudy weather.*" Various other causes have been assigned for the disease; the Rev. M. J. Berkeley, in an elaborate memoir illustrated by several varieties of parasitic fungi, attributed it to the insidious attack of a species of botrytis, which, singularly enough, had never been observed before, and was named in consequence by Mlle. Libert* (who is said to have first discovered it) "devastatrix," by M. Montagne "infestans," and by M. Desmazières, "fallax." When it was first noticed, it was said to thrive only on the living leaves of the potato, sparing even the stalks; it has, however, been admitted since, that it attacks the stalks and

* The Rev. M. J. Berkeley.

potatoes also; but in order to produce the disease of last season, as justly observed by M. Decaisne, it *must have* attacked *every plant*, which it certainly did not; for I most carefully examined the leaves and stalks of several crops last year at several intervals, with an excellent glass, without meeting it, except upon one occasion. We are also informed that the most skilful observers* on the Continent had examined whole fields without perceiving the least trace of this fungus; and M. Desmazières states that he had not been able to perceive more than five or six "boutons" of botrytis on many hundreds of infected potatoes. I have also examined a large quantity continually, and have very rarely met with any mildew at all resembling it, although other kinds were common. I cannot help thinking, therefore, from the recent discovery of this minute parasite, that its peculiar habits have been laid down with too much precipitation, sufficient time not having elapsed to afford proper opportunities of ascertaining whether it really was so much more dainty than others of the same family or not. I have met with certain cases which lead me to think it is not so. In March last I procured several diseased plants from a market-gardener, and, having placed one of the old sets on the border of a late vinery, in a few days a tuft of mildew appeared on it, the plants of which closely resembled a drawing of the botrytis infestans made from a leaf kindly sent me by Mr. Berkeley himself. The set was then in a moist state of decay. I also found a similar fungus on the 11th of April on some shoots pulled off diseased potatoes, and sent me from Sydenham, which had been lying on the same border ever since the 10th of February, being of course quite dead and brown. But what is still more remarkable, I found on the 11th of April a mildew in similar tufts, spreading over the mould in a flower-pot in which I had planted a diseased potato for the sake of experiment, and by sprinkling a little more moist earth over it I kept it still increasing for upwards of five weeks, although numbers of minute insects of the genus called Podura fed upon it as it became older, and quite consumed it. Many of these plants, as viewed under an ordinary microscope, could not be distinguished from those on the potato-leaf; but Mr. Berkeley, to whom I sent a portion of the mould, found two distinct species upon it, but did not consider *either* to be the true botrytis infestans; and I have since been able to satisfy myself that one of the species is not identical with that; and from Mr. Berkeley's high character, little doubt can be entertained as to the other. It may, however, be observed, that a wide difference exists in the several specimens of botrytis infestans with which Mr. Berkeley's memoir is illus-

* MM. Decaisne, Leveillé, Thuret, &c.

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trated. But whether or not these plants, or any others which I have found and drawn, are the true botrytis infestans (figs. 1, 2, 4, 5, A; and fig. 4, B), it is clear they must be very nearly allied,

A.

1. On dead shoots from diseased potatoes from Sydenham. April 11, 1846. Plants pellucid, tufts white.

2. On rotten moist stalks, from market garden. April 7, tuft white.

3. On Mr. B.'s leaf, April 16, the large plant floating over the edge of the leaf, when cut, pellucid; large clusters opaque if not in a good light; tuft greyish.

4. On mould in flower-pot, in which diseased potato was planted; brilliant pellucid; tufts steely white, some creamy afterwards. April 11.

5 On potato-leaf damped and placed over mildew, on flower-pot. April 11.

Drawn April 20.

a, *b*, *c*, *d*, *e*, *f*, sporidia which have discharged their contents on these plants.

Botrytis infestans.

as well in their habits as in general characters; for, having plucked a small leaf from one of my potatoes, and placed the under-side of it upon the mould in the flower-pot, in doing which the leaf, being damped, licked up a little fine earth from the surface, in eleven days I found the same species growing on the decaying leaf as drawn in fig. 5, A. It will be perceived that the plants thus obtained approach still nearer* in appearance to those on Mr. Berkeley's leaf than those do which were found on the bare mould, although they sprang from the spores of the latter. I also scraped a small portion of the under-side of a living potato-leaf, and stuck a little of the *mould* upon the spot, and in a few days that part of the leaf was covered with plants of the same species, but smaller than either those on the mould or those on the decaying leaf. The *fungus*, however, *did not spread beyond the spot* that *I had abraded*. Two things are proved by these experiments; namely, that plants of fungi, so closely resembling the

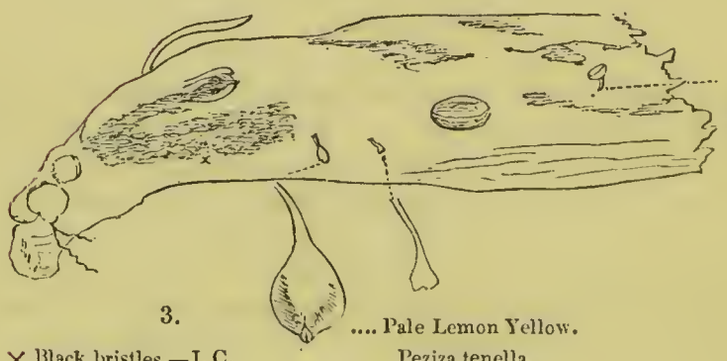
* Professor Henslow thinks it not improbable that uredo becomes puccinia; and I am quite certain these plants grew much larger and became more branched on moist decaying matter than on the living leaf.

botrytis infestans as not to be distinguished from it by the highest power of an *ordinary* microscope (I mean that called Dr. Hooker's), will grow on very opposite substances, and *that they grow larger on decaying matter* than on the living plant, on which they did not extend beyond the injured part of the leaf.

B.

1.
On dead potato stalk, smoky-yellow and black.—J. C., Feb. 1846.

2.
Smoky-yellow and black.



3.
× Black bristles.—J. C.

4.
From blotch on shoot from diseased potato. April 3, 1846.
All these plants on 1-7th of an inch by 1-16th of an inch.
Botrytis infestans?

From these circumstances, and from the fact that I have never yet seen the mildew on a healthy leaf, I cannot entertain the

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opinion that the botrytis took the initiative part in the late calamity. Indeed, I repeatedly rubbed leaves covered with it on the underside of my potato-leaves without producing any effect whatever; and I cannot but think that, if the leaves and stalks of the potato had undergone half as close an examination as to the state of their health at the commencement of the late attack, as they have subsequently for the discovery of mucedinous filaments, we should long since have arrived at a more satisfactory conclusion; whereas, little more than ordinary notice was taken of the *health* of the plants, while the mildew was magnified by a power equal to 780 diameters.* I have observed between twenty and thirty other kinds of fungi on the dead stalks of last year, as well as on diseased potatoes—of some of which I give figures, as they are very curious, and some of them I believe new; and I think the finding of them in such a situation confirms the general opinion that the proper food of fungi is, in almost all cases, matter at least in an incipient state of decay. I scattered the spores of many of these amongst the leaves of my plants also without injury to them. One of these, however (fig. 5, c), I found at the bases of many stalks at the time of taking up my crops last year; and since, upon upwards of two hundred stalks picked up indiscriminately, both inside and out; but, as it fructified freely during the winter, both in my greenhouse and out of doors, I look upon it merely as an attendant upon decay, not the cause of it.

Another opinion existed, that the disease was caused by insects: and, if the swarms of green flies which I found during my examinations of the haulm last year, on the underside of the leaves, had been generally observed, I should not have been surprised if such an opinion had been even more popular than the preceding. But the presence of this species has never, as I believe, been publicly noticed in this country, although, in America, in 1838, another species was observed by Dr. Harris,† in great numbers, on the potato-haulm and other herbaceous plants; and he thinks they contributed as much as the dry weather to diminish the crop by puncturing the upper parts with their *beaks*, drawing out the sap and poisoning the parts—for *these* shortly after *withered*, turned *black*, and in a few days dried up, or curled and remained stunted. The Doctor's odd description of their singular habit of "dodging round" to the other side of the leaf to elude being taken, in addition to a general resemblance, left no doubt on my mind of their being pretty closely allied to those which I found; but the Doctor describes his species as Phytocoris lineolaris. I did not perceive that those I found did any harm. I how-

* The Rev. Mr. Berkeley's memoir.
† "Treatise on Insects," 1841.

C.

1.

On decayed spot on vine leaf, April 20, pellucid stems, pale brown heads.

2.

On potato leaf, trial plant in pit, April 19, leaf decayed.

Monilia racemosa ?

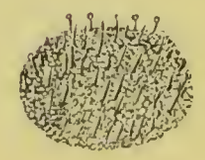
3.

On Dahlia shoot, rotted off May 4.

4.

On diseased leaf of tare, stems pellucid, sporidia yellowish, April 11, 1846.

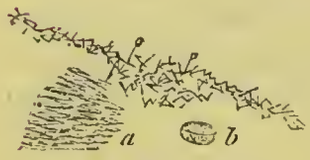
Botrytis Viciæ.



5.

On potato stalk, when taken up in October, like a grain of gunpowder; in groups, fructified, March 19, sporidia pellucid, bristles black, on *every* stalk where disease appeared.

Sphæria.



6.

On dead potato stalks in the winter. Like charred fibre on a pellucid thread—sporidia pellucid.

(*a*) Pellucid.

(*b*) Egg-like shell (sporidium) enclosing black fibres as above.

Physarum carboniferum.

7.

On dead stalks of potato in winter. Upper part snow white; lower, dirty yellow.

Peziza.

8.

On dead stalk in winter. An olive velvety mass, from a purplish stain at first; lower part black; upper, black and gold—very curious.

Helmisporium.

ever sent some of them to an eminent authority, well known to readers of the Royal Agricultural Society's Journal by his valuable papers; and his reply was, that he did not think them accessory to the disease. It is named by him Eupterix Solani, as it does not agree exactly with any named specimens with which he was acquainted. This far-famed disease, therefore, brings out a new insect as well as a new fungus.

I did not find the common Aphis upon the plants out of doors, but it attacked them seriously this year in pits, and injured both the upper and under surfaces of the leaves considerably. I also observed a small black fly, a species of Molobrus,* which bred amongst some old potato-stalks in my vinery, puncturing the

* M. fucatus, figured in the 'Gardener's Chronicle,' November 22, 1845.

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leaves on or near the veins, the marks of which might sometimes be traced a day or two afterwards; but I am not aware of any extension of the injury.

By some persons, I believe, it has been considered that a peculiar state of the atmosphere, as regards electricity, had considerable influence in producing the late disease; and, notwithstanding conflicting results have been published, both recently and fifty years ago, of experiments as to its effect on the growth of plants, I cannot come to the conclusion that it is an unimportant agent; for, in the application of so subtle a power, circumstances, with which in the present state of our knowledge we are unacquained, might negative the effect of it in one place and not exist at all in another. I am of opinion, however, that, in the case before us, electrical influence was not very considerable.

I do not consider it necessary to refer to any other causes to which this disease has been wrongly attributed; at any rate not in this place; and I will therefore at once proceed to state my own views of the true cause of the late calamity.

This I believe to have been no other than *Gangræna vegetabilis*, or, as it is commonly called, *canker*, a disease to which I have paid some attention for many years past. I may add, that my opinion does not at all depend upon the discovery of this disease in the potatoes at Bicton* this year, but arose from a close examination of my own last autumn, at which time Dr. Lindley also, more than once, pointed out the resemblance of the blotches to those of canker,† in the 'Gardener's Chronicle.' It is sufficiently known to most persons by its attacks upon fruit-trees; some of our most valuable sorts, as the Golden Pippin and Rennet and Ribston Pippin, being frequently destroyed by it—I believe, from a peculiar delicacy of constitution, which will not endure cold and wet situations, but will be perfectly free from it in warmer and drier localities: at least, I have found such to be the case with a Golden Pippin tree, which while in an unfavourable position was literally eaten up with canker, but, having headed it down to the stem and removed it to a light dry soil, and a situation much warmer than its former one,‡ it has stood six years without a single blotch of canker upon it, and last year produced a fine crop. On the other hand, I have had some sorts, such as the Quarendon, planted in the former situation, close to the above, without being in the least affected in twenty years, it being more hardy. Neither have I ever met with canker in the wild crab, or, to the best of my knowledge, in any indigenous plant—if even *that* be

* Feb. 21. † Aug. 23, 30.

‡ The leaves and shoots of those vines which ran out into the open border were much blotched this year and last, but others growing inside were perfectly clear and healthy.

so; for apples are said to be natives of Syria, and are alluded to in Scripture; although many of our oldest sorts bear French names, and no doubt were brought to us from Normandy. Apricots, and many other trees from warmer climates, are very liable to its attack, some varieties more so than others; thus, last spring, I had one or two branches of Moor-park apricot, which I had budded three years before on the common sort, destroyed, while the parent plant was uninjured, being, doubtless, more hardy. If a blotch of canker on a fruit-tree is examined soon after its appearance (which is often very sudden when hot days in spring are immediately succeeded by sharp frosts or cutting easterly winds), it will be found that the brown or ferruginous fluid corrodes the inner coats of the bark in an uneven manner, just as it does on the potato—usually forming a band or ring round the shoot. This, however, frequently throws out granulous matter, as an effort to counteract its progress, which is sometimes successful for a season; at other times, and much oftener, the canker is victorious, following the course of the medullary rays into the pith; the contest is then at an end, and the upper part of the shoot dies. It often happens also that two or three isolated blotches arise on the same shoot; hundreds of instances of which I met with on the stalks, as well as on the potatoes themselves, last year: in fact, it is characteristic of the disease to appear in that form. The potato-stalks, however, being more herbaceous, and constructed to endure only for a single season, become a quicker and more easy prey to its mortiferous foe. The same effects are likewise frequently produced on the leaves and stalks of many other tender and half-hardy plants when exposed to sudden and violent changes of temperature. Cauliflowers, if badly wintered, and cucumbers* and melon-plants, are more or less subject to this disease, and are soon utterly destroyed by it. Gardeners usually term it "damping," or "shanking off." Immense quantities of cucumber-plants were destroyed last season as stated in the 'Gardener's Chronicle'—some I witnessed myself; and if in circumstances favourable to its development, mildew, in one or other of its varied forms, succeeds. Several other plants† were affected in a similar manner; and the same disease has this year caused sad havoc amongst tulips, which looked very healthy during the early part of the year, but were struck by the cold and wet weather which ensued afterwards; many of the blotches on the leaves being also covered with mildew, as in fig. 1, D.

* The following answer was given, May 23, to a person who complained of his cucumbers being diseased, by the editor of the 'Gardener's Chronicle:'—"It is impossible to say what these cucumbers ail. They are cankered: one would have thought that they were overwatered in too low a temperature," &c.

† Carrots, onions, tomatoes, mangold wurzel, &c., of my own growth.

D.

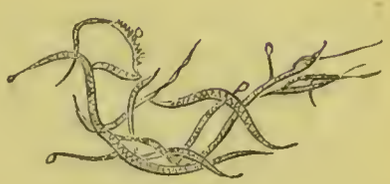
1.

Pellucid stems, pale green, heads with globose sporidia.

Aspergillus glaucus.

2.

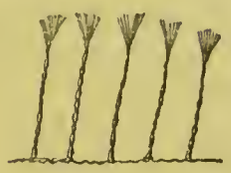
All pale brown, heads like brooms.



3.

Transparent, except the netted parts.

1, 2, 3, on starch bread (April 14, 1846) from potatoes.
No. 1, on decayed tulip leaf, May 11.



4.

Grey; stems pellucid; on potato, dark inside when cut, afterwards became as *hard as stone*. v. specimens.

Aspergillus penicillatus.

5.

Black, on putrid potato.

Pachnocybe subulata.

6.

Stems pellucid, sporidia whity-brown, on diseased potato leaf in pit; also on pith of dead geranium.

Monilia racemosa.

7.

In the middle of diseased potato, dirty yellow, shiny.

The potatoes at Bicton (Devon), under a melon-frame, were also described by Mr. Barnes, the gardener, as looking *quite healthy;* and others also, planted in borders in the open ground, looking very flourishing during January last, but, on the 9th, 10th, and 11th of February, sharp frosts occurred, and the mean temperature of the week was $1\frac{1}{2}^{\circ}$ *below* the average for the last twenty years: and what was the temperature of the week previous to this?—why 7° *above* the average for the same time. And what was the consequence? It is thus described on the 21st of February:—"Another sample from tubers, *supposed to have been sound,* also manifested the symptoms in *putrifying blotches on the leaves,* accompanied by the *underground grangrene.*" *

* Gard. Chron., Feb. 21.

On examining some sickly-looking plants of tares lately, which I found here and there amongst a very fine healthy crop, I was also rather surprised to find that this diseased appearance, instead of being produced by Botrytis viciæ (as it *has* been supposed to be), was, in *every instance,* owing to *blotches of canker, some* on the *stalks,* others *underground;* the greater number of diseased plants having no mildew at all on them; others, however, producing fine crops of Botrytis viciæ on the leaves, and Monilia racemosa, or an allied species, on the ulcerous spots on the stalks (fig. F). But I cannot perhaps name any plant by which the

F.

× Gangrenous blotches on tare plant. May, 1846.
1. Botrytis Viciæ on these leaves.
2. Monilia racemosa on stem (none on lower blotch).

real cause and nature of this disease may be so easily and clearly demonstrated as the common scarlet geranium, which, although considerably more robust than the potato, is, if ill treated, very liable to canker. Often have I seen this favourite plant, after enlivening our flower-beds during the summer, taken up in the autumn (usually after being a little nipped) and thrust into a dark shed, for want of better accommodation, and watched the "rise and progress" of the blotches on the stalks and leaves until the

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withering circle was completed round the stem. Sometimes *even then* it will not give in; the upper leaves will still retain their verdure in spite of it, while a particle of vital wood remains. (The Jersey Blue potato will, in good land, also stand out as stubbornly.)

On the other hand, I have seen, not only in former years but in the present one, geraniums which had been carefully nursed during the winter, destroyed in a few days by the same disease, caused by too sudden exposure to the variable weather of spring; sometimes without, but more frequently with, a copious supply of pump-water.

Analogous cases are mentioned by the celebrated Dr. Darwin, in 'Phytologia,' which I hope I may be allowed to introduce here, as they appear to accord so nearly with the phenomena of last season. He says,—"In the hot days of June, 1798, I twice observed several rows of garden-beans become quite sickly, and many of them to die, from being flooded for an hour or two with water from a canal in the neighbourhood; which I ascribed more to the sudden application of too great cold, after being much enfeebled or rendered inirritable by the excessive heat of the season, than to the too copious supply of water. On the contrary, when plants have been too long exposed to a *less stimulus of heat than natural or usual,* the spirit of vegetation becomes accumulated; and if they are suddenly subjected to much greater heat, their too great increase of action induces *inflammation,* and consequent *mortification* and *death*—as occurs to those people who have had too much warmth applied to their frozen limbs. Experiments of this kind were instituted by Van Uslar. He increased the irritability of *Euphorbia* peplus* and *esula* by secluding light and heat from them, and when he exposed them to a meridian sun they became *gangrenous,* and died in a short time."

In order, however, to bring the case quite home, I made this last experiment upon the potato-plant itself, in the following manner:—

On the 27th of December, 1845, I had planted 14 sound potatoes, and four in various stages of disease, in pots, and placed them in a small vinery, slightly heated by tan. Every one grew, but the sound ones the most vigorously; as may be seen by the accompanying specimens of their leaves. I never saw plants with more healthy foliage; for the season was unusually mild, not a single frost, I believe, having occurred during January, and I had not stinted them of water. On the 21st of March I selected the most flourishing plant from amongst them, and, having watered it thoroughly, set it at once in rather a dark corner of a dairy with a glazed window, which was closed at night and open by day—

* Succulent plants.

the temperature was then 40°, it being usually 44° while the plant was there. On the 2nd of April I brought it up, when the only apparent difference in it was, that it was not of so dark green a colour as when I placed it there. Still it was by no means etiolated. I at once set it in the sun, which was then bright, and at five o'clock P.M. *brown spots* appeared on three of the leaves.* I continued to set it out by day, although the weather became dull, and protected it in a cool pit at night. On the 6th of April nearly all the *leaves* were *blotched,* more or less; but, although I examined every one separately with a Stanhope lens, *I found no mildew on any one.* On the 20th of April several petioles *doubled down*† at the places where blotches had formed, and the upper parts SWUNG BACKWARDS and FORWARDS in the air, as I remember to have seen them *last year;* and on one withered spot there was a species of mildew (fig. 6. D.). On the 30th of April only two leaves at the top were free from blotches, and SEVERAL OF THESE HAD FORMED ON THE STALKS. I subjected another plant to similar treatment a short time afterwards, and THE RESULT WAS THE SAME; the figure (E) being composed of stalks and foliage from both plants, as seen May 16th. I afterwards took another victim, which is now (May 23rd) in a progressive state of decline. The two former plants were turned out of the pots on the 29th of May, in the presence of a gentleman to whom I have before referred, but none of the potatoes were diseased, although the roots of one plant were quite withered. The other had not become diseased down to the roots. My own opinion, however, remains the same. One of the most eminent botanists in the kingdom, to whom I communicated my experiments, also concurred in my views as to the nature of the disease; and assured me that he did not consider that this at all invalidated them—as, however near I might come, it was almost impossible, in such an experiment, so to control the elements as to render circumstances exactly alike, and that the blotches on the haulm alone proved the identity of the disease. Being in a pot might make some difference. Many plants last year had no diseased tubers, although badly diseased in the haulm. Every other plant in my vinery continued in perfect health, except two, which I shall mention presently. On the 20th of April a sharp frost cut the forward potatoes out of doors, and, *early* in the morning of the 21st, drops of brown fluid were resting on the leaves, very similar to that seen in diseased potatoes. I plucked some of these leaves, and inserted part of one of them under the bark of a potato-stalk in my vinery. THIS has produced a LARGE BLOTCH quite round the stalk, and SPOTS ON THE LEAVES ALSO, which will in a few days *destroy the*

* *Vide* specimens.

† *Vide* fig. E.

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E.

Ash-leaf potato (trial plant), drawn May 14, 1846. × Monilia racemosa.

*plant.** I have since tried it on another, and this is also working in the same manner. This experiment I consider most important, for it not only shows that *cold* suddenly succeeded by *bright sun* (as it was between six and seven o'clock on the morning of the 21st of April) will convert the sap from its natural colour to brown, but, from its having acquired thereby a *phagedenic property*, it also points to the same causes as the origin of canker, and thus confirms the view which I have taken of it in a former part of this essay.

It also proves the correctness of its analogy with the effect on frozen limbs as mentioned by Darwin. And does it not also show that canker is neither more nor less than the *mortiferous principle* of the *vegetable system*, as the true gangrene is of the animal? For, if either is arrested before it has entered into the general circulation, both animal and plant may be saved, but, if allowed to extend into the more vital parts of either,† death is

* This plant was sent to the R. A. Society's Rooms, where it died in a few days.

† I saved several bunches of grapes last year by cutting out the blotches on the stalks as soon as they appeared.

inevitable. By what means then, it may be said, are plants saved from total destruction after being nipped by frosts? I answer, they frequently *are* entirely killed, but if bright sunshine ensues, as in the case I have cited, the tissue of the frozen part is ruptured, and the sap *escapes* as I saw it; continuation of sunshine dries up the frozen parts, and the margin of the injured spot is healed by matter thrown out by the vital energy of the plant. If, however, a plant only slightly affected by frost is watered all over before the sun shines on it, and shaded for some time afterwards, it will recover entirely, as I have frequently experienced, if it be in good health at the time; but if it had been previously exposed to unfavourable conditions, by which its health had been, as it were, secretly undermined, I would not answer for its not becoming diseased or gangrenous in consequence: the vital energy of a plant depending upon certain conditions adapted to its own peculiar nature, and its diseases or premature death upon the partial or total deprivation of them.

Slips * of diseased potato it is well known will produce disease, if inserted into others; but simply bruising a sound potato will produce no such effect. In order to ascertain the nature of canker still further, I inserted slips of apple-tree canker into some potatoes as well as into their stalks; I also made a *decoction* of slips of cankered wood in a dormant state, and introduced it into the living stalks by puncturing them with the point of a knife; I also inserted slips of diseased potato under the bark of apple and pear-trees, but by no one of these experiments did I succeed in transferring the disease, but a very little of the *decoction* soon produced a blotch on the shoot of the vine (fig. 1, c). It appears, therefore, that the *mortiferous principle* of plants requires some affinity in the plant with which it is brought into contact, otherwise it will not assimilate its juices to its own condition, although not so close an affinity is required as for grafting or budding, as the canker of the apple-tree produced gangrene on the vine, with which a graft would certainly not unite.

Amongst other eminent authorities, the opinion of Dr. Lindley has been throughout that the disease was produced by atmospheric causes. Lately, however, he has entertained a doubt whether Count Gasparin had not good reason for attributing it to some unaccountable miasma, such as causes cholera and other epidemics, on account of the disease having appeared under circumstances in which atmospheric changes such as I have before described did not occur. To this I can only say that Count Gasparin's tables of the weather may be accurate, but I cannot

* They also destroyed carrots and onions, but did not injure cabbage-plants.

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help again referring to the testimony of M. Decaisne and other authorities on the Continent, that the weather was as I have before stated, wherever the disease was observed by *them*. And as to its occurring under glass, I will mention one case which I witnessed, in which, under a mistaken notion, a sudden change was admitted to a range of pits planted with potatoes, which were nearly destroyed in consequence. The proprietor informed me himself that these potatoes had only had water twice since they were planted (I believe he added in November, and I saw them in March, when they had potatoes as large as eggs upon them), and upon those occasions the lights were removed to admit showers of rain. To this, therefore, I attribute his loss, as well as to the fact that a great many squares of glass were broken. They had, in fact, received too sudden and copious a supply of air and water after having been for three months stinted of both: and this is not a solitary instance. *Some grown close* to these were *perfectly healthy*.

To my mind, therefore, the sudden and extreme alternations of the weather last season, by imitating which as closely as circumstances beyond my control would permit, I have artificially produced the same disease upon the potato this year, were of themselves quite sufficient to produce the late almost universal calamity; for it has been shown that these causes prevailed generally, not only in Europe, but in America also, on which continent Mr. Robertson informs me that it is a well-known fact that the potato cannot be grown south of Washington, owing to the constant occurrence of such weather, and he further adds, "Should we happen to be visited with the kind of climate that prevails south of that city, we must expect to experience the same results." And I entirely adopt these words in reference to our own country, and only beg leave to add to them, "*and not otherwise*."

I should be sorry to say, however, that the disease could not be produced in any situation by other means than those which I have shown will induce it; for, from my recent experiments, I am quite satisfied (and I know I do not stand alone) that it is not near so difficult a task to render a plant diseased as some persons may imagine, but there are plenty of cases in which the finest theories carried out by first-rate practice fail to produce a healthy condition. But no case has hitherto come to my knowledge for which I do not consider the causes I have assigned to have been amply sufficient. The plant having been rendered partially inert by the repellent action of cold, wet, and gloomy weather, uncongenial to its nature as an exotic from a warm climate, at that critical period of its growth when in the course of ordinary seasons it would have been about to acquire strength and hardness, but

during which time it was incapable of perfectly evaporating its redundant juices for want of sunshine; they accumulated in consequence, and became vitiated by stagnation in that crude state; and when fine hot weather ensued afterwards, the sudden rush of sap was too great for its debilitated tissues, and the diseased fluid showed itself at the surface in various places, on the leaves and stalks, sometimes in spots not larger than a pin's head, at others in blotches, which rapidly increased if the stimulus of heat was kept up.

The virus of these spots, being of a phagedenic or ulcerous nature, eventually descended into the potatoes.

The effect upon these has been already described at the commencement of this essay, and has been also so well shown by Dr. Lyon Playfair in his comprehensive lectures, that it must be quite unnecessary to repeat it, particularly as he has illustrated the subject by such accurate diagrams.

As to the chemical action of the disease I am not competent to give an opinion. Dr. L. Playfair has stated that he considers it to be owing to oxidation of the debilitated tissues. But Mr. E. Solly attributes it to putrefaction of azotized matter in the stems, but also implies that it might arise from oxidation, if the tissues *were* debilitated, which he, however, doubts. But for my own part, I cannot conceive it possible for plants to be rendered incapable, during a long period of the growing season, of performing their most important functions *without their being enfeebled*, and thus, if this point were conceded, as I believe it generally is, very little difference would exist on this head between two of the most eminent agricultural chemists in this country.

Much has been said about the disease being contagious. Strictly speaking, it is not so, for I had three roots of Shaws taken up on the 29th of August, containing twelve sound and nine unsound tubers, which I placed on the bare ground, taking care to make the diseased parts touch the sound ones. I then covered them over with their own haulm and an old mat. I examined them frequently, and lastly, on the 21st of March, when the twelve sound ones were still without blemish, eight of the others were diseased all over, and one had only the upper eyes sound. In February last I also had twenty bushels of perfectly sound potatoes, picked out of a heap of bad ones with which they had been thrown when they were dug up. I have since had these cut, and, finding them perfectly sound, used them for sets.

It was supposed, from an experiment made by Mr. W. Crum of Glasgow, that *all* potatoes last year contained the principles of disease, in consequence of the pulp when grated turning first ferruginous and afterwards black. But I have found that, if the potato is scraped with an ivory knife instead of an iron grater,

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the colour does not become darker than usual, but remains of a darkish fawn. Of course a white potato should be used, not a purple one. I cut one in halves, scraping one half and grating the other, and there was considerable difference in the colour of them, much of the black tint being no doubt owing to the action of the acid of the potato on the iron of the grater. I am still of opinion, therefore, that, as so many potatoes have kept perfectly sound up to the present time, these had in no way imbibed the principles of disease.

If I have been right in attributing the late disease to atmospheric causes, it must follow, *strictly speaking*, that there can be no remedy for it in the power of man capable of general application. *That* must be left to One who has given its peculiar seasons to every land and its unalterable laws to the humblest herb. Still it is our duty to try every means. Lime and sulphur may in some cases under glass be of service in destroying mildew, but I have seen them tried without the least advantage as to curing the disease. The only effectual remedy, if it may be so called, is to pull up the haulm entirely as soon as the disease has seized the stalks; a great many potatoes were saved by those who adopted this method, although they will not be quite so good as if they were left to ripen on the haulm. Cutting off the haulm will not be so efficient in many instances, as the lower parts of the stalks are often as bad as the upper parts. Those who cut the haulm off *before* the spots appeared upon it, however, state that it was equally effectual. The above will, I believe, be the only means of mitigating the effects of the disease, if it should appear again, which I do not however in the least anticipate,* unless an equally ungenial season should occur, in which case it would probably be more severe; and where persons have not been particular in planting sound sets, if on wet cold land, I have no doubt they will have a weak and gappy crop; for, although I have raised healthy potatoes from diseased sets myself, and have seen the same produced by others, yet they are not to be relied on out of doors, as I have before experienced.

Preventive measures are perhaps more in our power than remedial, namely, to plant only sound sets in light open well-drained and well-prepared soil, with less manure than usual—for, as Miller truly observes, the wall-flowers which grow on old walls seldom rise so high, and have tougher roots, and firmer stalks, and smaller leaves than those which are planted in gardens; but in severe winters, when these are frequently killed, those upon walls will receive no injury. And there can be no reason why potatoes grown on a poor light soil should not also become more

* At present they look beautiful everywhere.

hardy. Certainly, those I grew last year on poor light land did not suffer so much as those on stronger soil; and although there may be some exceptions, I believe this to have been generally the case.

I consider on light land well prepared, dibbling holes* for the sets between every other furrow is as good as any other plan; for when the sets are placed in drill-furrows, if heavy rains ensue, the drill forms a trough for the water, which rots the sets. I have had a great many destroyed by this means, while sets from the same stock, dibbled, were uninjured. But I do not recommend dibbling except on well-prepared light land. This should be kept clean with the hand-hoe and stirrer, and when about a foot high the potatoes should be earthed up slightly, so that a small *channel* shall be left with the stems in the middle of it. I do not like planting sets cut *very small:* I prefer them an inch and a half in diameter. I am also decidedly averse to autumn planting, as a general system; for, besides the danger of frosts and thaws, there are many insects in some soils which would leave the sets mere shells. I have not had much experience in raising seedlings; but have grown a few sown thinly in shallow drills in light vegetable mould—one root produced upwards of thirty small tubers; and to raise the largest possible crop from a given number of sets, no plan can surpass that practised by the late T. A. Knight, Esq., who is said to have raised almost incredible crops by it. His plan was, to keep the surface round the plants slightly stirred, and to add a small quantity of fresh light mould to them as their roots extended towards the outside, and to repeat this occasionally throughout the season.

I might add more on this subject, but find it impossible to improve in any respect upon the very excellent Essay of Mr. Henry Cox, in the last volume of the Royal Agricultural Society's Journal, which ought to be read by every grower of the potato. I will, however, take the liberty of adding two sorts to his list—the White Scotch Kidney, which is a great bearer in good land, resembling the Ash-leaf, but larger and of excellent quality, and the Jersey Blue, which is an immense bearer, hardy, perhaps the longest keeper, and when grown in light soil, free from core, and boils to a mass of flour.

I always avoid taking them up in wet weather; there is fermentation enough in a heap of potatoes if never so dry. I had mine last year laid up in ridges 4 feet wide at bottom; then roughly thatched with straw sufficient to keep out rain. They remained thus for three weeks, the weather being very fine; they were then carefully sorted a second time, which was more easily

* This plan produces from 8 to 12 tons per acre on my land.

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done now, as the skin of the diseased ones had peeled up. The best were then put into a cool shed, lightly covered up with straw; the others were packed in ridges, covered over with dry mould, and then well thatched. They all kept well, but those in the shed the best. I had some packed with lime and others with ashes, but they were no better than those without any, which kept as well as usual, not more than two pecks of bad being found in a ton late this spring.

Certainly the best way, and I believe the most economical in the end, is to put potatoes into a house constructed on purpose for them. They are then accessible at all times, and the pickers (usually women) need not be exposed to all kinds of weather in the winter. A house upon the following plan, the owner informed me, had fully answered his expectations for the last fifteen years, during which time he had not had a peck frozen in it. It is constructed in the following manner:—Posts are fixed in a row in the ground, about 3 feet apart, 6 feet 6 inches out of the ground, to support a plate. The same is done on the opposite side, about 9 feet wide. Tie-beams are then fixed across (about 6 feet apart) from plate to plate; a doorway is framed at each end, and one in the middle. The walls are then built up outside the posts with turf and strong loam or clay, 3 feet thick at bottom, closely rammed and sloping to about 2 feet thick at top; rod-hurdles are then placed across the tie-beams, and on these bad hay or old litter of any kind is built up like the roof of a hay-rick; and when properly settled, it is well thatched over nearly down to the ground. The doors are blocked up during hard weather with litter.

As any rough posts *will do*, if sound, the cost is very moderate. This house is 140 feet by 9 feet, inside width. Probably one or two trunks, like water-spouts, passed through the roof, with caps to close down, might be useful as ventilators in a house of this size; and similar trunks perforated would, I doubt not, be of advantage if inserted in all large heaps of potatoes, especially if wet, whether in pits or houses.

Potato-house. 100 feet, 9 feet inside width.

I have omitted mentioning that I tried dipping the diseased potatoes in strong solutions, but I found that, in proportion as the disease was checked externally, it spread more rapidly within. Nothing seems to preserve them better than keeping them dry and cool.

I have at length brought this mysterious subject to a close, and hope I have sufficiently explained the nature of the disease and such palliative or remedial measures as are really useful; but I have endeavoured to be as concise as possible, knowing that most persons have become weary of the subject. Should, however, any additional information be required, I shall be happy to afford it as far as lies in my power.

May, 1846.

Supplementary Observations on the Growth of 1846.

My ash-leaf potatoes were nearly killed down to the ground by the spring frosts, but afterwards rallied and looked healthy; they, however, turned off sickly in June (which was very hot) without any appearance of mildew, and I found only one diseased tuber among them.

The Shaw, of which I had two acres growing where a potato had never grown before, were short in the haulm, and turned off by the middle of July, being nearly ripe. The skins were set the beginning of August, but, being apprehensive that, after such great heat and drought, if heavy rains ensued, they would be attacked with last year's disease, I had taken the precaution to pull up the haulm (which had several times flagged during the intense heat) before any mildew appeared, with the exception of a small portion for observation.

I first observed the mildew on the 8th of August. It commenced in the middle of a field of seven acres, on a spot where a pit had been filled in with strong clayey loam, the rest of the field being a sandy loam. A sort of bowl was formed in this place, and the haulm was very luxuriant a few days before, when my women complained that they could not get through it to cut down weeds. On looking for this spot on the 8th I was startled at the sight of a circular patch of blackened stems, the lower parts naked from the leaves having fallen from their axils, and the upper part of the foliage green and brown, and glittering with the botrytis as with frosted silver, the under surface being curled over the upper. No microscope was required to discern it this year; it was perceptible at a distance of several yards, and continued to spread in a circle up the sides of the bowl. I examined the tubers, and found the greater part of them diseased as far as the pit extended,

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but no farther. I had the whole of the haulm, except a small patch for observation, pulled up without delay, as I found the Botrytis infestans, which is at least an infallible indication of the disease, had attacked some of the lower leaves slightly all over the field. On taking up the crops, the Shaw contained five pecks of diseased in 100 bushels. The blue, being later, contained 13 bushels in 350 bushels, but 10 bushels out of the 13 came from the pit and the part immediately surrounding it. On the drier parts of the field there was scarcely a bad potato. It is also very remarkable that in the grounds of my neighbours, right and left, the disease commenced in filled-up pits, and the tubers were in those parts much the worst. It was in a similar situation in the year 1841 that I observed my potatoes affected with the same disease; and a very extensive grower has since informed me that previous to his draining his fields he has sometimes lost 20 tons by the same rot in wet autumns. The blotches on the stalks I find denote the second stage of the disease, and I was anxious to have my haulm pulled up before these appeared,—for which the weather was favourable. With much wet and a close atmosphere the gangrenous process is very rapid, and the botrytis multiplies greatly; but during drying winds and bright sunshine the latter is not developed, except in very damp situations. I gathered during the dry warm weather a great number of blotched leaves, on which I could not discover the botrytis with the highest power of my microscope; but on putting a drop of water into a wine-glass and inserting the petiole, and placing the glass in a close shady place, a crop of it was produced within two days. By this means I have raised finer specimens of it than ever I have found out of doors. I inoculated the leaves of several potatoes with the botrytis by scraping the underside with my nail and rubbing an infected leaf upon them, and, if the weather were gloomy and close, it would appear in two or three days, but if dry, and a brisk wind prevailed, in an open situation, it would sometimes not grow at all.

Having kept two or three potato-plants in my greenhouse for experiment during the summer, which were perfectly healthy on the 13th of August, the atmosphere of the house being then moist, I inoculated two or three leaves of one of them, which I had also subjected to experiment in the spring, and set an infected plant taken up on purpose next to it, but up to this time, October 14, only five of the leaves and petioles, which are not more than three inches apart, are withered; the atmosphere of the house having subsequently been kept drier for the purpose of ripening grapes, with good ventilation; the vitality of the plant has a second time overcome this injury, and the rest of the foliage is quite green and healthy. Still I do not doubt that the botrytis is a very

powerful agent, under peculiar conditions of the atmosphere, in accelerating the decay of the potato-plants, but I am of opinion that it will not attack them except they are predisposed, nor spread itself except in a close humid atmosphere, for another plant kept all the time in the same house, but not inoculated, has not had a blotch upon it. On the 19th of August I observed a tomato-apple with a blotch similar to those on the potatoes, and, having placed it in my book-case, on the 30th I perceived a thick crop of Botrytis infestans upon it in full fructification, the sporidia being so distinct that I could discern the internal structure of many of them, and even the points at their summits (Fig. 3. a.). The leaves, stalks, and fruit were blotched like those of the potato, both this year and last; but although they have a somewhat greyish appearance underneath, I have never yet found the botrytis upon the leaves, notwithstanding I have placed them in situations likely to promote its growth, which seems also to negative the idea of the blotches themselves being produced by botrytis. On examining the blotch on the fruit a few days later, I found a thick crop of another (Fig. 4.) species of fungus, with globose sporidia on short stems without branches.

I have also found the Botrytis infestans growing on the inside (Fig. 5 and 6) of the tomato from which I had cut a diseased portion.

I have entered thus fully into particulars relating to the botrytis, as it has, I believe, been everywhere manifest on the potato-leaves this year, but I have seen nothing to shake my conviction that, although a powerful one, it is only a secondary agent in promoting their decomposition.

The mildew on the specks called the scab, of which I have figures, is also only occasionally developed—indeed it is difficult to find a specimen of it. The scab being a cutaneous affection, the specks are merely the result of some improper accretion being thrown off, and I suspect that the small white spots observable upon the skins of some varieties (as upon apples) denote the position of glands provided for some important purpose, and the impure fluid which escapes at these points becomes the favourite pabulum of a little dainty parasite.

I have, however, another species to notice even more minute than the Botrytis infestans, but (as it appears to me) performing an office on the underground stem at least as destructive as that species on the leaves. It has been supposed, from the fact that the underground stem has been frequently found in a scurvy unhealthy condition previous to the disease being seen in other parts of the plant, that it invariably breaks out there first. There are, however, many exceptions to this; indeed, such are the variations of latitude, soil, heat, moisture, &c., under which the plant is grown, and by which it is undoubtedly affected, that it would probably be as easy to

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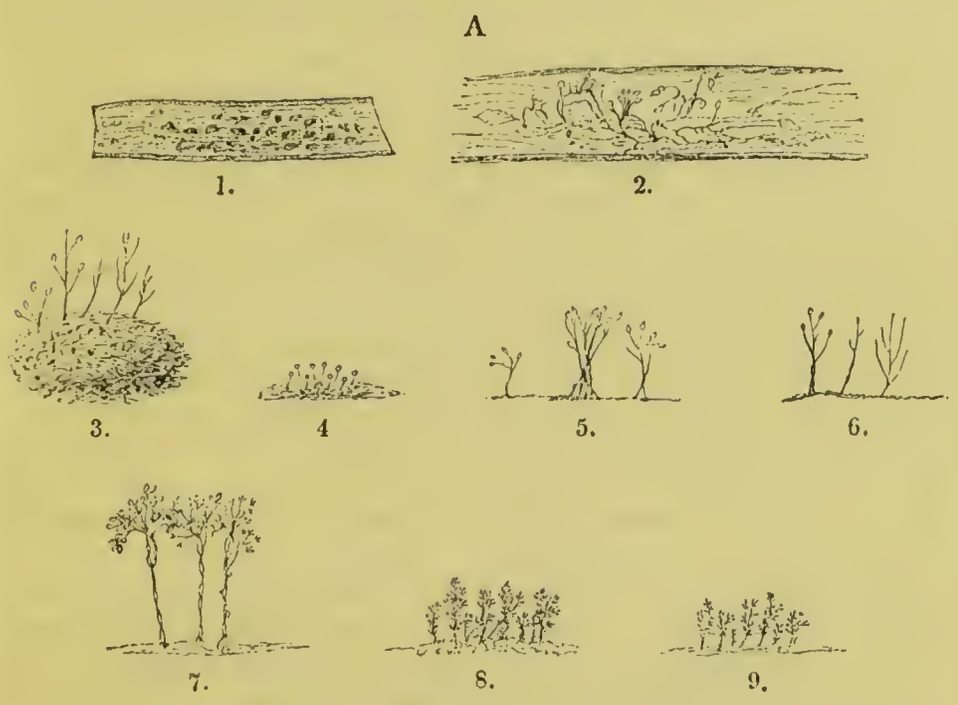
account for one person escaping from a malignant epidemic to which his neighbour fell a victim as to account for every phase of this mysterious visitation. But if the rusty spots on the underground stems are carefully examined, it will be found that small white specks of mildew exist between the bark and woody part, and also frequently occupy the internal tissue of the bark itself, even in a greenish state.

There are apparently two species; in an early stage being somewhat like jelly, but in a more perfect form resembling the accompanying drawings (Figs. 1 and 2), one species being not



1. Inside of bark, underneath a rusty spot, on underground stem of potato, showing a number of white specks of mildew in an early stage, the brown spot not having encircled the stem. Sept. 7.
2. Most likely the above mildew in a more perfect state. The sporidia, being very transparent, appeared to be filled with spores; some had burst. On inner bark of underground stem of potato. Sept. 8.
3. Botrytis infestans, on green tomato, diseased like the potato.
5 and 6. The same on ripe tomato, outside and inside of a blotch, beautifully vitreous. Sept. 26.
4. Another species on diseased tomato.
7. Botrytis parasitica, on lettuce leaves. Sept. 24.
8. White mould on underground stem of potato.
9. White mould on scab on potato, apparently identical with No. 8.

unlike that produced on the scab (Figs. 8 and 9); but I have not been able to ascertain the names of them, *if they have any*. With regard to these species I am of opinion that, like the botrytis, their proper food is vegetable matter in an unhealthy condition. I shall only further observe with respect to fungi, that many species have been unusually prevalent this autumn;

the common plantain, groundsel, peas, clover, brocoli, turnips, gourds, cucumbers, lettuces, and many other plants and fruits having been attacked, and some destroyed, each by its peculiar parasite, after being reduced to an unhealthy condition by weather calculated to depress its vital energy.*

I shall next notice the several insects with which the potato-plants have been infested, and to some of which the disease has been ascribed. Numbers of aphides which feed chiefly on the under side of the leaves, probably on the fluid contained in the glandular hairs with which they abound, appeared on the 13th of July, some of which were punctured by parasites, and from which I bred the Aphidius avenæ, and also Ceraphron Carpenteri,† which destroys the larvæ of the Aphidius. Perfect lady-birds and their larvæ were also feeding on them in considerable numbers. The Eupterix solani‡ appeared July 20th, and multiplied very fast, for I found soon after some of all sizes as well as their eggs, which are oval, white, and ribbed lengthwise; but I could not breed them. I also found another species distinguished by black spots on the wings (Eupterix pieta). Having watched these beautiful flies inserting their beaks into the leaves of the potato for a quarter of an hour at a time, and noted the places exactly, I can safely say that blotches did ensue on some of them, though not on others; and possibly their punctures might render the leaves more accessible to atmospheric injuries or even to the spores of botrytis. Be this as it may, if any insect which I have seen is necessary to the disease, I believe, from the innumerable swarms of them thrusting their long beaks into the leaves, it must be these. I afterwards found a very minute creature called Smynthurus. He is rather ugly in shape, and sometimes in colour not unlike a tortoise. He can leap well, but is not very shy, for I watched one or two of them for a long time greedily devouring some loose filaments of botrytis; these, therefore, were doing no harm. I also found the Thrips minutissima,§ but not in any quantity. This is rather shy, and the larvæ would sometimes let themselves down by a thread which they spun: they seemed to feed upon the pubescence of the leaves, as a shiny patch was often observable with the hairs closely mown off as it were by them. I also found the green

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* It is well known that many plants, such as cabbages and turnips, recover from the effects of mildew after having been entirely covered with it; and this season I had some cauliflower-plants attacked as soon as they were in the rough leaf, yet, having been well watered, they recovered entirely, and produced a crop of very fine heads in November.

† Agricultural Journal, by Mr. Curtis.

‡ First noticed by me last year, when I sent specimens to Mr. Curtis, who figured it in the 'Gardener's Chronicle.'

§ Figured by Mr. Curtis in 'Gardener's Chronicle.'

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bug Lygus, first noticed by Mr. Balkwill, who said the disease was caused by the acrid fluid discharged by it. I squeezed this fluid on some leaves of the plant in my vinery, and the mark is visible still (Oct. 10), but it never extended farther. I also caught a great quantity of the Altica exoleta? on the leaves, which they nibbled into innumerable holes. I found also the red spider in some places feeding on the under surface, and causing the leaf to assume a whitish appearance, as it does in cucumber and melon plants. I placed all these species upon the potato-plants in my vinery, but, with the exception of the inoculated leaves, they are perfectly healthy now (two months since, October 14). On the 23rd of July, however, I found a plant in my field, two or three of the lower leaves of which were rather sickly, and, when taken up, it had one diseased tuber attached to it. The specks which I have alluded to as being white on the skin of the healthy tuber were in this brown and filled with putrid matter, which, when removed, left a small hollow like a cup: the corrupt fluid exuding from each of these cups or glands (as I suppose them to be), it becomes the nidus for a tuft of mildew. Not seeing cause enough to account for this diseased tuber, I split the underground stem, when I found in the inside the larva of the Molobrus (bred from diseased potatoes last year, and figured by Mr. Curtis in the 'Gardener's Chronicle'), as shown in the drawing I have made; but whether this small

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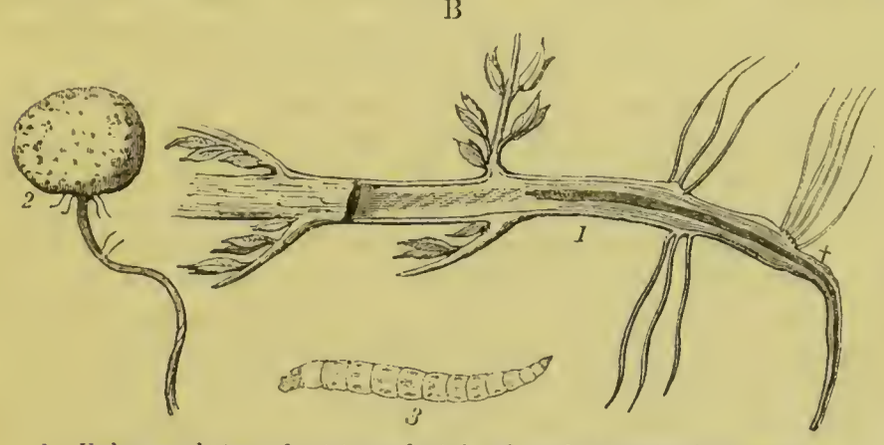

1. Underground stem of potato, perforated and partly eaten by the larva of a fly, Molobrus fucatus; bred by Mr. Curtis amongst diseased potatoes—the stem diseased, as also the lower roots—foliage sickly. July 23.
2. Diseased potato attached to the above stem, at the + the cord rusty-brown.
3. The larva magnified.

maggot had promoted the disease in the tuber or not is more than I can say; but I think not, for the following reason:—I had a piece of potatoes, with oats on each side, which I feared the wire-worm would have entirely destroyed. Suddenly, however, they recovered, and soon after many of the potatoes began to flag and

wither, and, on pulling them up, the underground stems were riddled through and through, with wireworms sticking in them, many fibres being also gnawed off by them, but the tubers were not diseased, and are sound now (December 9th). It is, therefore, my opinion that no injury the plant may receive from insects will of itself produce the gangrene, by which it is unquestionably destroyed.

I will now endeavour to describe the progress of the disease, having had opportunities of observing it this year at an earlier period than last. It usually commences in a semi-transparent blotch on the underground parts, which is formed by brown, shiny, extravasated fluid between the epidermis and inner bark, sometimes only on one side of the stem or roots; and, if the soil becomes dry and the weather fair, it penetrates through the bark rather slowly, but progresses rapidly in a damp soil with a close humid atmosphere. I have marked several of these blotches in their transparent state as soon as formed with bits of thread, and find that, sooner or later, according to the circumstances above mentioned, they assume a scurvy, opaque appearance outside, but, by cutting through this, the shiny fluid may generally be seen within. The blotches in the tubers change in a similar manner, and the progress of the gangrene in them is accelerated or retarded by the like circumstances; the blotches on some of my potatoes last year, which were kept dry and cool, not having penetrated more than 1-8th of an inch up to the end of March, having, however, assumed a dull sunken appearance in place of their former glossiness.

Previous to my having traced the rustiness of the stems to the original transparent blotches I entertained some doubt as to its connexion with them, from the fact that the inner bark of the specimens which I had before examined was apparently healthy, and the discolouration entirely confined to the epidermis, which had become dull, dry, and wrinkled. Now, however, I am convinced that the one is the result of the other—the epidermis having lost its transparency by corrosion of the fluid, which is also withdrawn by absorption to the inner parts of the bark, leaving the outer coats nearly dry. Similar blotches appear about the same time, or soon after, on the roots and cords. Sometimes, however, the leaves are blotched first of all. I have found many very large plants with nearly every leaf and the stalks likewise blotched, the leaves being covered with botrytis, while the roots and lower parts of the stems remained quite clear; but I have never seen until the 24th of October diseased roots or cankered stems supporting healthy foliage.* Hence it appears that the

* Oct. 24. On finding many healthy-looking plants in my field (grown

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disease does not uniformly originate in the underground parts, but that the plant is stricken throughout its system by an ungenial,

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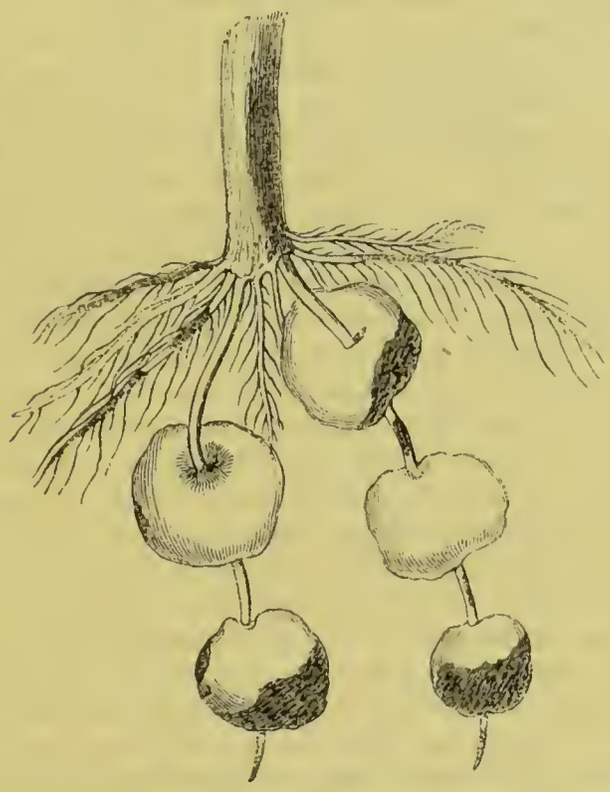

Underground stem of potato, showing the isolated gangrenous blotches on the stem, roots, cords, and tubers.

or rather by a pernicious, state of the atmosphere; the effects of which, as amongst animals, breaks out sometimes in one part and sometimes in another. Owing to the extreme excitability of the plant this season in consequence of the long drought succeeded by heavy rains, a second and a third production of young tubers were formed like a string of beads—those of more recent formation upon cords thrown out by those which were older (Fig. C). Yet the shoots from the youngest were very frequently diseased, while the older cords and tubers were to the eye perfectly sound, —so strong a tendency has this disease to show itself in unconnected blotches. The rapid or slow destruction of the haulm and foliage depends upon the same conditions as that of the roots and tubers; sometimes it is effected in twenty-four hours; sometimes

from potatoes left in the ground when taken up last July) I pulled up several of them, the foliage of which was without a blemish, and to my surprise *found the gangrenous blotches just forming on parts of every root*. It is quite certain therefore that the particular part on which it breaks out is sometimes above and sometimes below the surface of the soil.

it will not be completed in six weeks. I believe it has been much more rapid in many parts this year than last.

The same disease is said to have visited St. Helena in 1840, and Ireland as well as America in former years. I am also quite certain that I had it amongst my crop in 1841, and then it was confined to a spot where pits had been filled in. To account, however, for its breaking out so universally as it has these last two years, is a task which I cannot undertake, believing, as I do, that it may arise from transitions of various kinds and degrees, which conviction I have come to, not only from the effects of my own experiments, or the bare fact that the present season differed in many respects from the last, but also from the testimony of old residents and writers of acknowledged credit in various parts of the world. From these I learn that, in parts of America and South Australia, where extreme heat and drought are suddenly succeeded by drenching rains, the potato cannot be successfully cultivated; and in others, for the same reason, it is never attempted; while in Western Australia, which is not so subject to violent changes, the potato does not degenerate. I have no doubt, therefore, although I cannot personally account for the peculiar effects of which the potato is susceptible in foreign countries, that, if the disease can be satisfactorily accounted for in a single garden, it will be found upon due inquiry that the same general cause has existed with more or less severity wherever the disease has appeared—I mean a sudden and extreme change in the state of the weather. When had we such a summer as that of 1845? —such extreme heat succeeded by long-continued gloom and chilling rains, with a temperature almost reduced at times to the freezing point? Again, in 1846, January passed without a single frost; intense heat prevailed during June and July, on the 19th of which last month my thermometer reached 100° in the shade of a tree at half-past three p.m., and 83° on another day while buried six inches deep in the earth in one of my potato-beds, being equal to the bottom heat required for the pine-apple!

On the 5th of July it was hotter in the shade, I believe, than any day on record in this country; and throughout June and part of July the thermometer only ranged from 4½ to 8° above the average for the last twenty years, according to the register kept at the Horticultural Garden; but we know not how much longer. I have also been assured by an old resident at Rio Janeiro that it has been quite as hot in Yorkshire this year as at Rio, where the potato is not grown, but imported by the packets. During the intense heat the potato-plants flagged in many places, and on the 5th of July, with the thermometer at 95° in the shade, torrents of rain descended, accompanied by an unusual storm of thunder and lightning; in the morning succeeding which, so dense an exhala-

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tion * arose, that I could not discern a tree at about three yards distance—the atmosphere being upon this, as well as upon other similar occasions during the summer, extremely oppressive; and it is, I believe, certain, that this same kind of weather prevailed nearly all over England about the same time.† On the 1st of August another storm burst upon us with terrific thunder and lightning, and around the metropolis a shower of enormous hail-stones; and a similar storm, with the exception of the hail, occurred again on the 5th. Here and there a trifling complaint of the disease had been previously made; but, the plants having been subject to artificial treatment, this might arise from particular causes, from which I believe the potato has always suffered; but a very few days after the last storm the outcry became general that the potato-crops were again stricken. The weather, however, became subsequently dry and warm, with a clear air favourable to evaporation, which in light friable soils well drained has rendered the injury much lighter than it would have been; but in heavy undrained soils the loss has been very serious—in some places, especially with the late varieties, amounting to total destruction of the crop. As regards a remedy, I believe the only safe plan is to prepare the ground in the autumn by draining, deep trenching, or ploughing, using a moderate quantity of manure, and planting as early in the year as the weather will admit; and should the disease attack the crop, I am certainly in favour of pulling up the haulm as soon as it is perceived, for I found many more diseased tubers beneath those roots whose stalks I left standing than where the haulm was pulled up; and had the latter part of the season been less propitious, I have no doubt the bad ones would have been in far greater proportion. It has been stated by Mr. Gilbert, of Ealing, that where he had his ground trenched two spits deep he had scarcely an unsound potato, but that where it was dug only one spit deep there were a great many diseased, although the sets were from the same stock—all partially diseased, and planted contiguous to each other. Whether they were planted at different seasons or not I am not aware; but if this plan should prove as successful upon all occasions, it is very important; as it not only shows the advantage of deep tillage, but would afford much additional employment during the winter season. It has also been said by some persons, that where they planted unsound sets the crop was uninjured; but where sound ones were used that it was as difficult to find a sound potato, as

* To this fog, and a similar one last year, the disease has been attributed by a correspondent of the 'Gardener's Chronicle,' Oct. 31.

† The county of Northampton, or a great part of it, is said to have suffered very little, and its produce supplied many London dealers in October, as I was informed by a large salesman.

in the other case an unsound one. From this many persons may conclude that they have only to provide a store of unsound sets in order to secure a good sound crop next year. But let me warn such persons, at least, not to place their sole dependence on such a rotten foundation, for I can assure them, from actual experience, (although success may have attended the practice this season, on account of the soil and weather being in a favourable state for promoting vegetation during the former part of the season,) that had the soil been harsh, and the weather cold and wet subsequently, the shoots would have been attacked with gangrene soon after they were formed, and the greater part of them would have perished. In 1841 I lost nearly an acre in this manner, the sets having been cut from tubers obtained at Tooley-street, diseased in precisely the same way as at the present time; while of the crop adjoining, from sound sets, I lost scarcely a plant.

It may appear to some persons that, because the present season has not been precisely the same as the last, the cause of the disease cannot be referred to the atmosphere. Yet so universal has the calamity been, that it seems to me almost impossible that it could be produced by anything else—for, what other subtle medium pervades the whole globe? What, short of those extremes which destroy plants entirely, is more injurious to their health than sudden and violent transitions? And have we not had these? Yes; and in so unusual a degree in both years, that every man who notices such occurrences at all, would, independently of their disastrous consequences, long remember the years 1845-6. Until these changes ensued, the crops in the open ground looked sound and healthy throughout the country. I do not notice those grown in open borders through the winter, as they are clearly exposed to too many vicissitudes, however skilfully managed; nor need I more than barely refer to a few diseased crops, which may have been produced in neglected or badly managed pits—while in adjoining gardens I have known plants in perfect health, owing to the superior skill of the gardener in protecting them from atmospheric injuries. Of such men, there are many who know that in an unsuitable atmosphere the organs of plants cannot perform their proper functions, and that, as soon as these cease, the plants themselves become the prey of gangrenous ulcers, parasitic fungi, and noxious insects. But in an inquiry of this kind we must look chiefly to the effects upon the general crop; and this, I repeat, appeared in perfect health until those changes took place, to which I have before referred; but soon after, every plant, young or old, became affected. Subsequently, however, the weather here became more moderate, and many plants which I have seen growing out of doors from this year's tubers, as well as one or two plants which I have since grown in my greenhouse, were appa-

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rently quite free from disease. A similar result is recorded by Mr. C. Chapman, of Brentford, in the 'Gardener's Chronicle' of 31st of January, who planted some on the 1st of July, the produce of which were all diseased; and others on the 1st of October, taken from the same stock as the former—the produce of which proved all sound. "It appears clear, therefore," Mr. C. says, "that (probably about the end of July) there was some peculiar atmospheric change, which, combined with other things, attacked the haulm of the potato, and through that diseased the tubers." If these changes become periodical in this climate, I do not doubt that England will in a few years cease to grow potatoes to any extent; but I must say that I have never heard of any common plant being lost to cultivation from such a cause, nor do I see any probability of such sudden and extreme alterations becoming permanent in a country the climate of which is proverbially fickle.

Dec. 11, 1846. F. J. Graham,
Cranford.

XXVI.—*A Report on the Feeding of Stock with Prepared Food, and a description of the Apparatus employed.* By Joseph Marshall.

Prize Essay.

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The author of the following observations does not pretend to have discovered any new way to feed cattle; nor can the objection of novelty, the current and groundless objection of every foe to improvement, be justly urged against the system which he has adopted, and which he thinks others may adopt, if they will, with advantage. The principles here laid down have been long, though, perhaps, not generally known. All the merit which he claims is, that of having persevered in spite of friendly remonstrances, ridicule, commiseration and the like, in a course which his own reflection and calculations recommended, and which his own experience, and the larger experience of more able and scientific farmers have since proved to be successful. That success has arisen, not from the discovery of any new principles, but from the proper carrying out of principles already *known*. It has been long *known* that the use of prepared food is more wholesome and more economical than the use of raw food. Frequent attempts have been made to prepare food for stock, but either from the imperfect description of the apparatus employed, from the improper mixture of materials, from the unwholesome state in which the food has been given, or from some other cause, these attempts

have often proved failures. Why they have proved so he is not called upon to show. One tenant thrives on the same farm on which another has starved. One man feeds, and another cannot feed, cattle. Probably the same reason may have influence in both cases.

But that cattle and other stock may, with ordinary care, be fed upon food artificially prepared in the method here described; that the saving in consumption will more than repay the attendant labour and expense; that an opportunity will be thus given for consuming inferior corn of unmarketable quality at home with advantage, as the cattle thrive well upon it, and the sample taken to market is rendered better; these are facts beyond doubt.

We now proceed to state, as briefly and clearly as we can, how the operation has been conducted; to speak of the food, its preparation and effects, and make such remarks as may from time to time suggest themselves.

On the author's farm the food is prepared, and all other work connected with the system performed, by one man, except the grinding of the corn into meal, which the foreman takes and superintends, being done at a corn-mill. Dean's linseed-mill is used for crushing the linseed, and Clawdray's chopper to cut the straw.

The best artificially prepared food which we have hitherto found is boiled linseed, ground corn, and cut straw, along with some raw turnips, given at intervals. A heifer weighing from forty to fifty stones will consume, daily, two pounds of crushed linseed, boiled in three and a half gallons of water for two or three hours, five pounds of ground corn, ten pounds of chopped straw, and about eighty or ninety pounds of yellow bullock-turnips, with a little straw, not cut, placed in their racks at night. The cost of food thus prepared from the following statement, in which no charge is made for straw and turnips, and in which ample allowance is made for coal, labour, and outlay of capital, appears to be 4*s.* 4*d.* for each head per week.

Cost of prepared food for twenty-two head of cattle and three draught-horses for eight weeks in 1844 and 1845:—

	£.	*s.*	*d.*
2688 lbs of linseed, or 48 lbs. per day . . .			
192 lbs. do. not used on Sundays, deducted			
2496 lbs., or 46⅓ bush. of 54 lbs. at 6*s.* per bush.	13	18	0
458 stone ground oats, at 11½*d.* per stone . .	21	18	11
8 weeks wages, at 13*s.*	5	4	0
1 cwt. of coal per day, at 15*s.* per ton . .	1	1	0
Interest on outlay of 50*l.*, wear and tear 8 weeks	1	5	9
	£43	6	8